

VISIT...

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Brain- Machine Interfaces

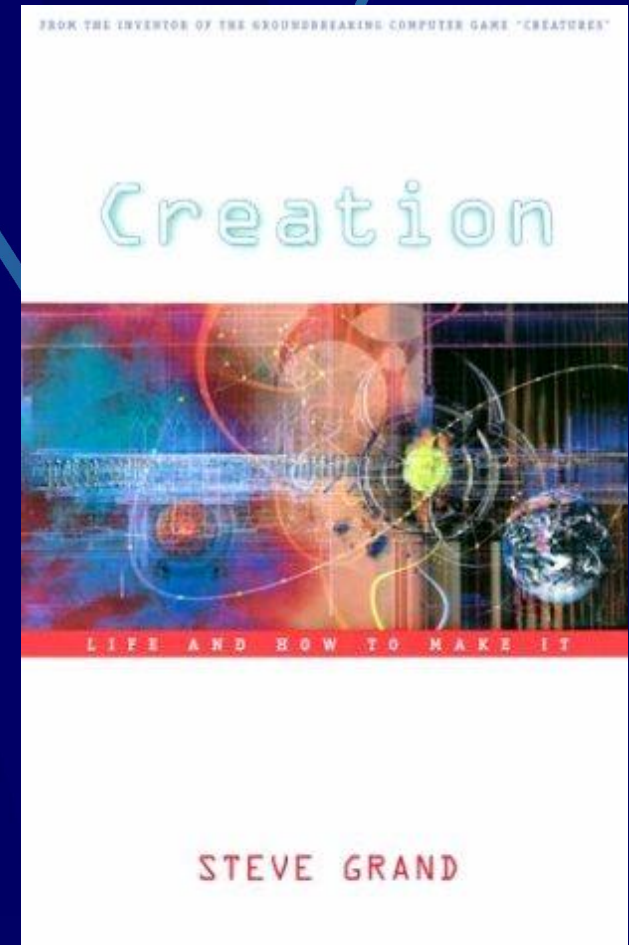
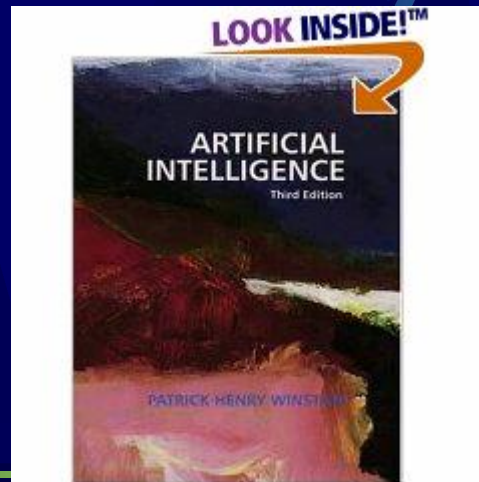
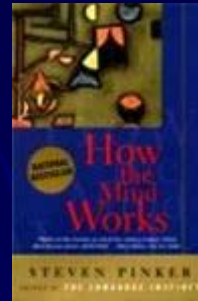
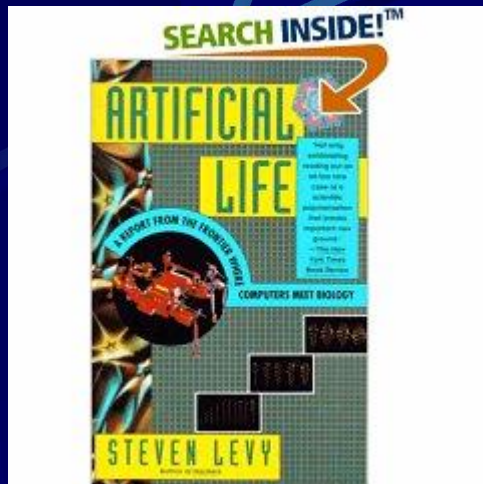
The link between Neurosurgery
and Artificial Intelligence

Steven Falowski, MD

Ashwini Sharan, MD

Thomas Jefferson University Hospital

Present Literature



Media



History

● René Descartes

- Founder of “Modern Philosophy” and “Modern Mathematics”
- Bodies are complex machines
- Invented the Cartesian coordinate system



The Beginning

- DBS
 - Pain Disorders
 - Chronic Pain
 - Psychiatric Disorders

Where are we Now?

- DBS/Neuromodulation
 - Parkinson's
 - Epilepsy: Vagus Nerve Stimulator
- Neuroprosthetics

Neuroprosthetics

- Artificial devices used to replace damaged or missing parts of the brain
 - Cochlear Implant
 - Visual prosthesis/retinal implants

Cochlear Implant

- Stimulates nerves
- Need some nerve fibers
- First implanted in 1978



Retinal Implants

- Used in diseases of progressive blindness
- Degradation of photoreceptor cells
 - macular degeneration
 - retinitis pigmentosa
- Two chip System
 - Recognition
 - Transmission

The Idea

● Now

- Neuromodulation
- Neuroprosthetics

● Future

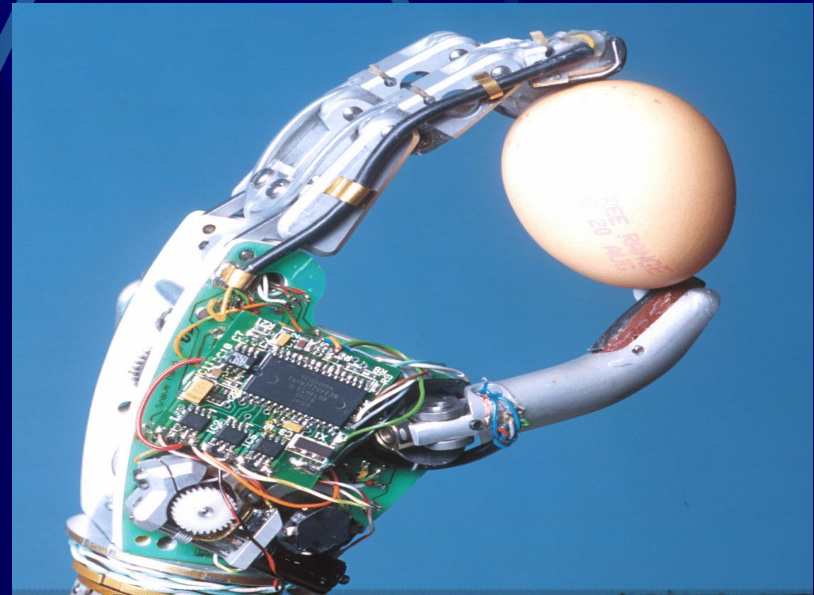
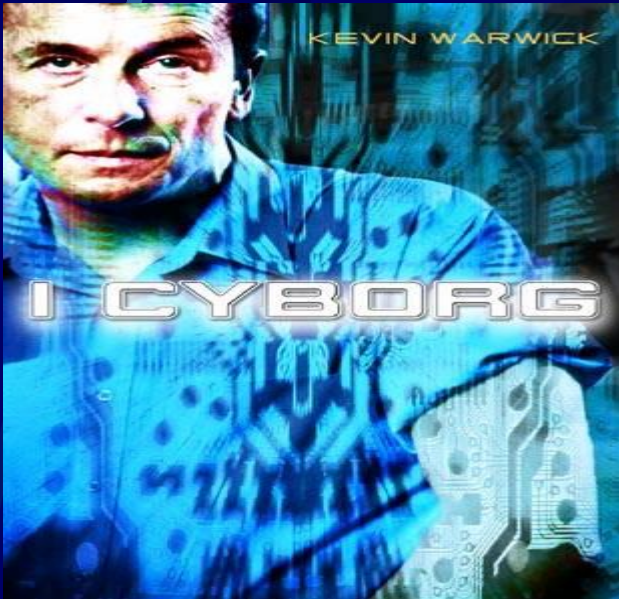
- Enhancement
- Replacement

Where we are Going

- Neurocontrol
 - Functional Electrical Stimulation
- Brain- Machine Interface

FES

- “Cyborg”
 - Kevin Warwick/University of Reading
 - Implanted electrode array into his forearm
- Used recordings for different functions
- Controlled an artificial hand



Brain- Machine Interface

- Neural Networks
- Four main Functions
 - Motor
 - Sensory
 - Behavior
 - Intelligence/Cognition

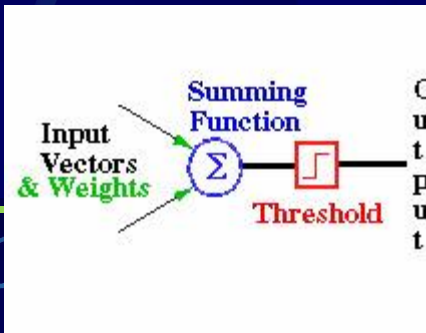
Neural Networks

● Backpropagation

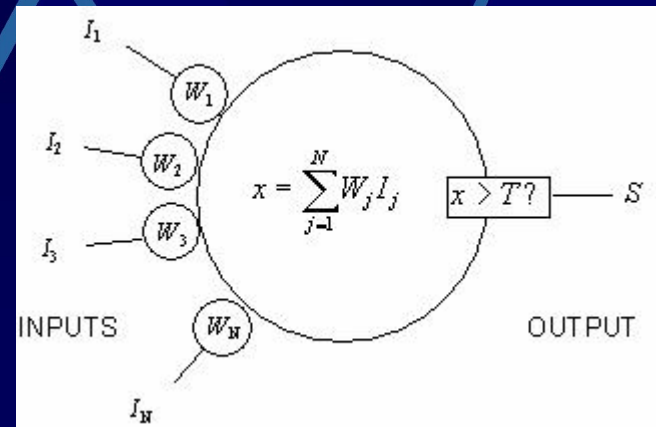
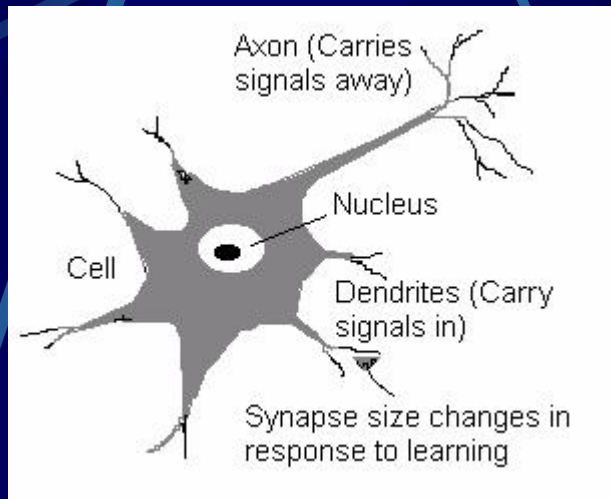
1. Present a training sample to the neural network.
2. Compare the network's output to the desired output from that sample. Calculate the error in each output neuron.
3. For each neuron, calculate what the output should have been, and a *scaling factor*, how much lower or higher the output must be adjusted to match the desired output. This is the local error.
4. Adjust the weights of each neuron to lower the local error.
5. Assign "blame" for the local error to neurons at the previous level, giving greater responsibility to neurons connected by stronger weights.
6. Repeat the steps above on the neurons at the previous level, using each one's "blame" as its error.

Neural Networks

- Based on the Perceptron
- Perceptrons can be added in series or parallel.
- Summation of input and output vectors
- More networks=increase speed



Neural Networks



Comparison

● Conventional computers

- use an algorithm
- Restricts it to problems with known solutions

● Neural Networks

- Learn by trial and error
- Functions by example

Brain Implants

- Biological neural networks: Stimulate one or groups of neurons
- Made of silicon or platinum
- Mimic neurons
- Replace damaged or dead brain cells

Important Considerations

- Complexity of neural connections
- Stable connection
- Plasticity of the human brain

Answers?

- Create bridges for damaged cells
- Compatible brain tissue or molecules that will adhere to brain tissue
- Sensory Substitution

Another Consideration

- “Brain in a vat” theory
- Can stimulate and train the brain increasing capacity



Brain- Machine Interface

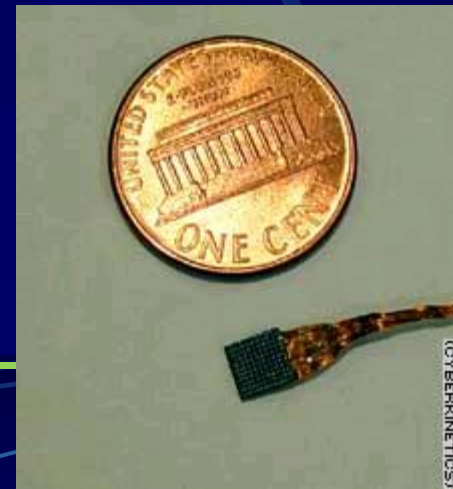
- Four main Functions

- **Motor**

- Sensory
 - Behavior
 - Intelligence/Cognition

Motor: Transforming Thoughts

- Cyberkinetics developed a system called BrainGate
 - Microchip on the motor cortex
 - Transmission to a digitizer and then computer system for translation



Transforming Thoughts-1

- Neural Signals
 - Uses a device implanted beneath the skull
- Helsinki University
 - Virtual keyboard
- NY Rochester Institute of Technology
 - Computer-brain interface
- Colorado State University
 - EEG recording of various tasks
 - Writing, visualizing numbers
 - Uses a computer interface

Transforming Thoughts-2

- Initial goal is interaction with computers and basic functions
- Future goal is to implant electrical probes directly into muscles

Monkey think, Monkey Do

- Dr. Nicolelis/Duke University
- Implant allowing monkey to control a game using thoughts
- Monkey could play using only visual feedback



How it works

- Microelectrodes along the frontal and parietal lobes
- Computer system recognizes patterns of signals when monkey moves



Relevance

- Transmitted to a robotic arm
 - Can control another device to move objects
 - Can then use artificial limbs in paralyzed people

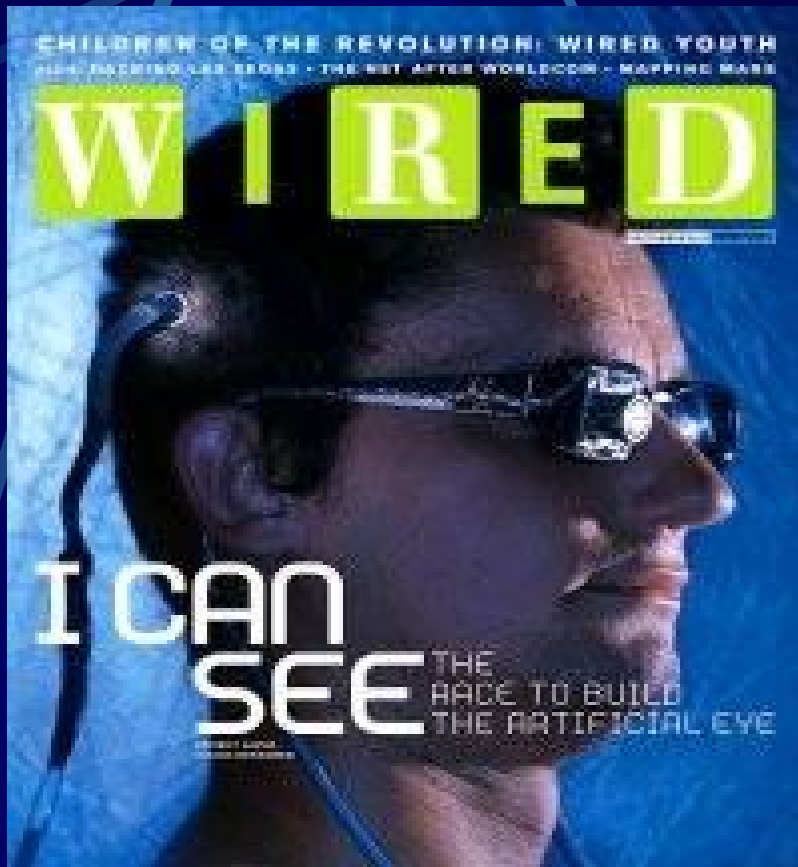


Brain- Machine Interface

● Four main Functions

- Motor
- **Sensory**
- Behavior
- Intelligence/Cognition

Artificial Vision



- Research involves using either sensory substitution versus direct cortical stimulation

Brain- Machine Interface

● Four main Functions

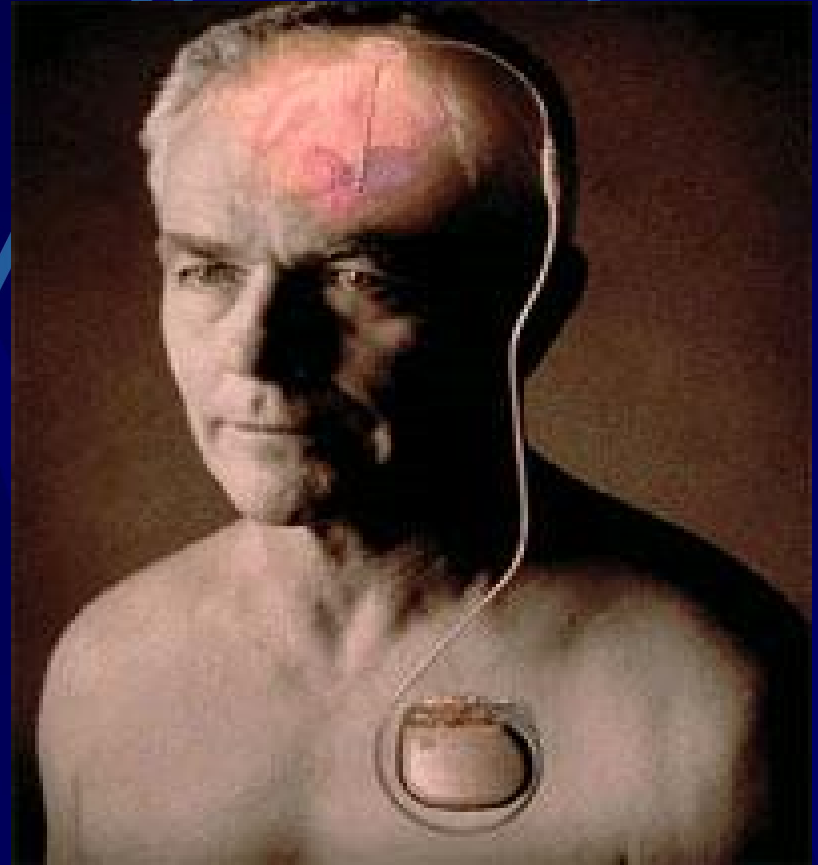
- Motor
- Sensory
- **Behavior**
- Intelligence/Cognition

Behavior

- OCD(ventral striatum and midline thalamus)
- Depression

Depression

- Constant, weak electrical stimulus to area 25
- Study of six patients
 - 4 improved

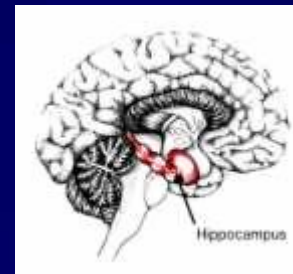


Brain- Machine Interface

- Four main Functions
 - Motor
 - Sensory
 - Behavior
 - Intelligence/Cognition

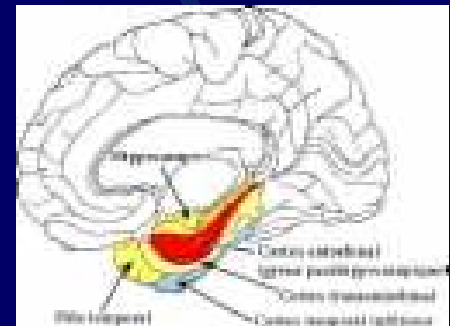
Artificial Hippocampus

- Studied at the University of Southern California
- Hippocampus is very ordered and structured
- Strictly involved in formation of new memories



Artificial Hippocampus

- 2003 Devised a mathematical model of hippocampus
 - Slices of rat hippocampus were stimulated with electrical signals
 - Each electrical input produces a corresponding output.
 - Programmed onto a chip



Artificial Hippocampus

2004 Used a grid of miniature electrodes to feed signals in and out of the microchip

- Compared rat hippocampus slices to the chip
- Signals matched in shape, timing and statistics

Next Step: implant in rats and then in Monkeys

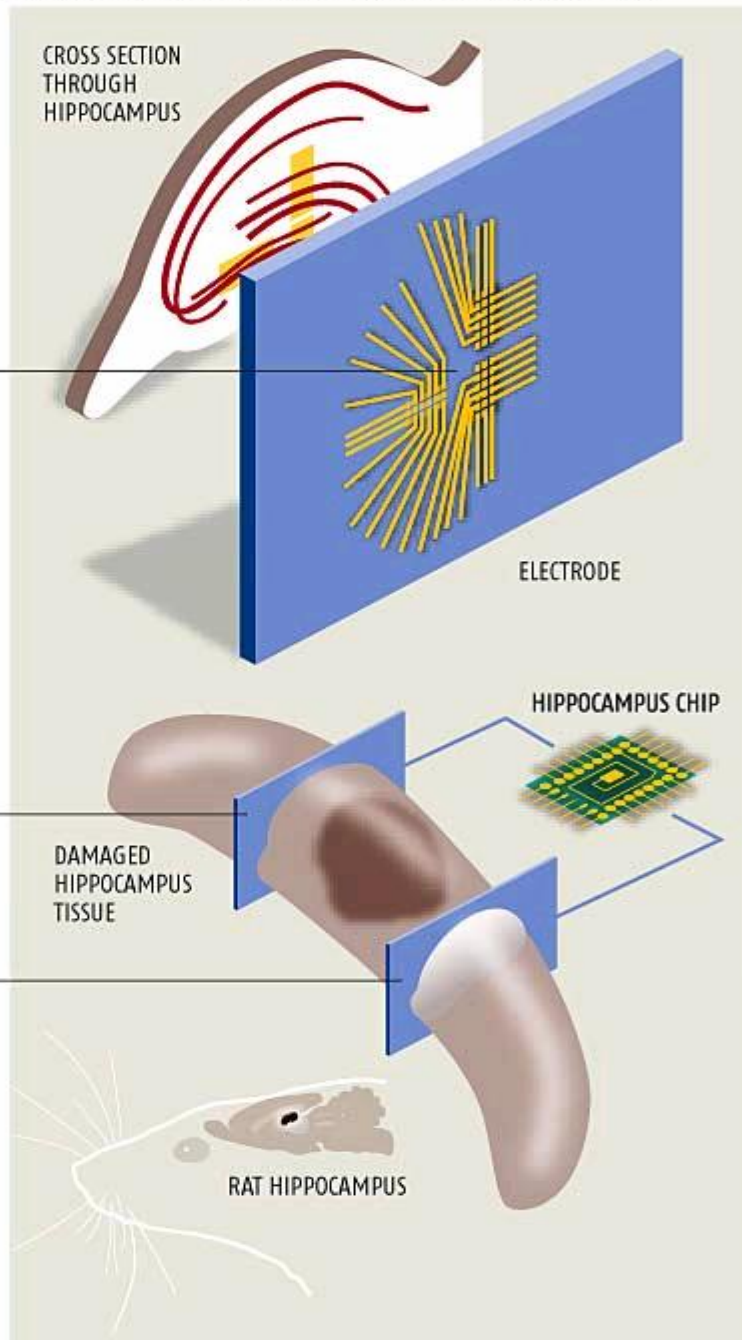
HIPPOCAMPUS REPLACEMENT

Chip takes over the processing of nervous signals normally performed by the hippocampus

Multiple electrodes are placed on each array. They are positioned to mimic the structure of nerve tissue within a slice of the hippocampus, and make contact with other parts of the brain

Recording electrode array "listens" to neuron activity coming into the hippocampus and feeds it to the chip

Stimulating electrode array delivers the appropriate electrical output to the rest of the brain



Problems

- Making long- range connections to other parts of the brain
- Bypassing healthy tissue
- Development of scar tissue as well as cell death of previous neurons
 - electrodes coated with proteins that should mimic healthy tissue

Artificial Intelligence(AI)

- Intelligence exhibited by an artificial entity.
 - Behavior
 - Learning
 - Adaptation

Artificial Intelligence(AI)

- Research in AI is concerned with producing machines to automate tasks requiring intelligent behavior.
 - Planning
 - Scheduling
 - Problem solving

Schools of Thought

- Conventional AI
 - AKA: Machine Learning
 - Demonstrates applied reasoning
 - Example: Clippy

- Computational Intelligence
 - Interactive
 - Learning
 - Example: Consumer product control systems

Present Uses

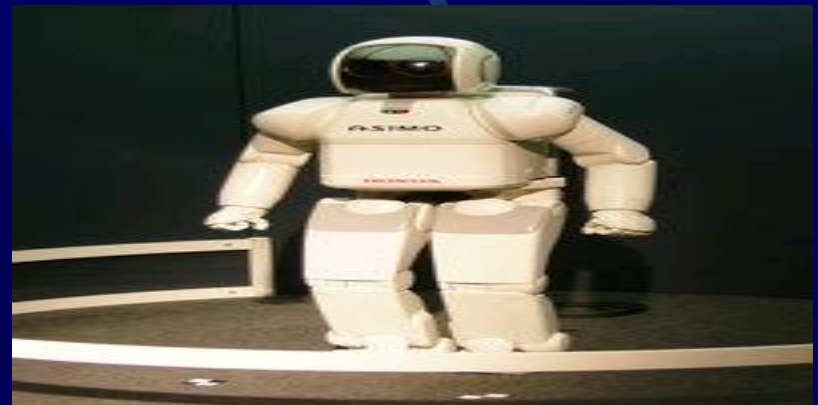


- Government uses AI computers to schedule units
- Gaming
 - Virtual reality
 - Image Processing
- Robotics
- Automation

Where AI is heading..

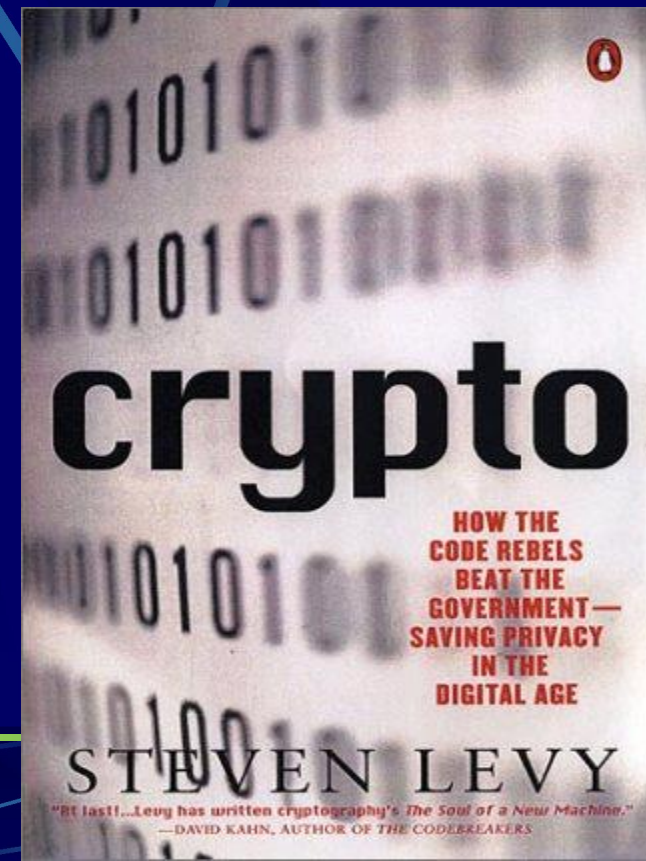
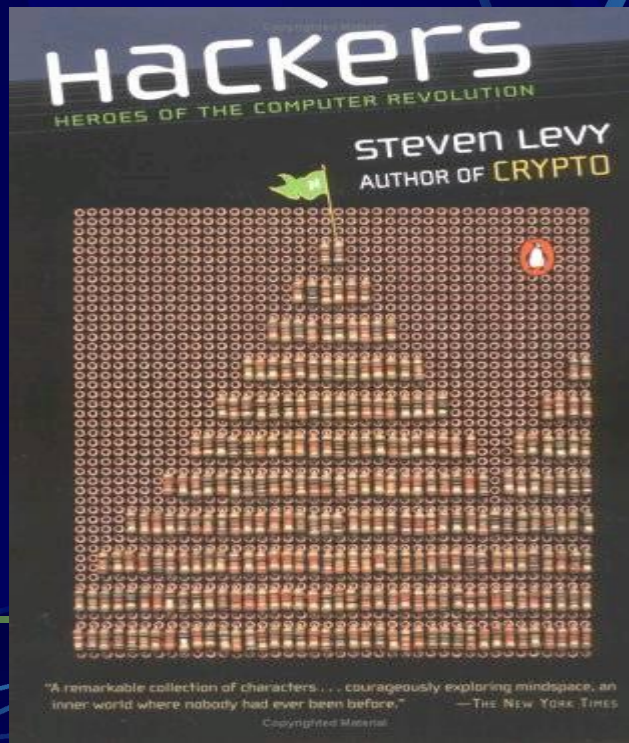
- Space Exploration
- Deep Ocean Exploration

- Virtual Reality
- “Android Robots”
- Douglas Lenat-A
common sense knowledge base



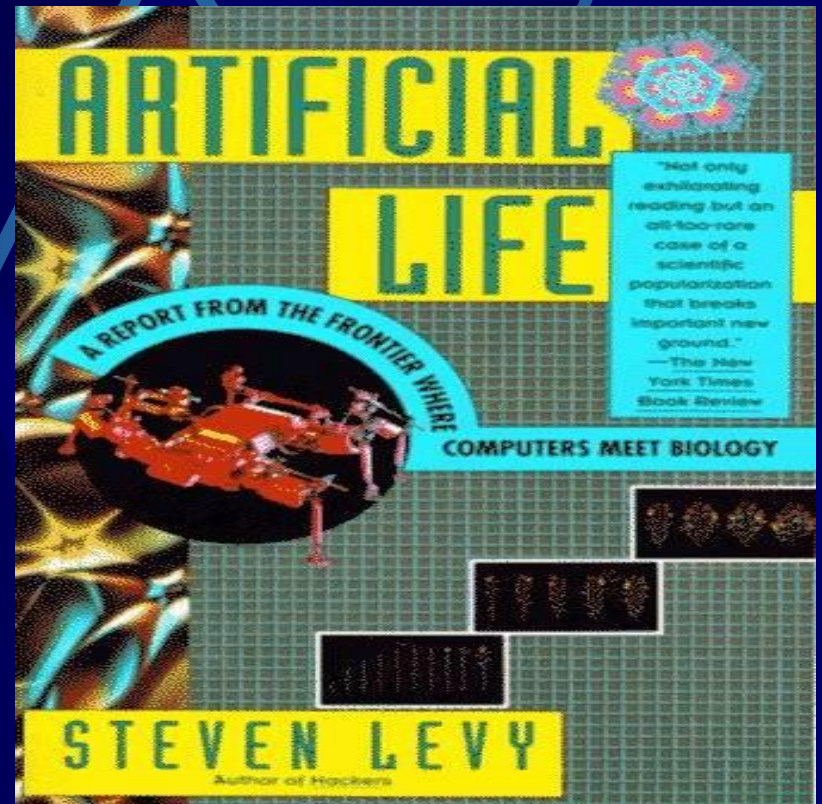
Steven Levy

- Based on Biological behaviors
- “Natural” rules



Steven Levy

- Life “in silico”
- Computer viruses are close to becoming “life”
- Artificial organisms that meet criteria of living creatures



Artificial Intelligence in Medicine (AIM)

- More evidence based medicine=more information=more reliance on computers
- Can the medical profession rely on the computer to make the right clinical assessment?
- Diagnosis is a process, not an event and fortunately, human cognition is still superior to machine intelligence

Ethical Issues

- There is little or no reason to create mechanical laborers (that can think independently)
- What is considered the type of human being to design as an “Android”
- Inability to understand complex interactions

Ethical Considerations



- Can you give consent?
- Could implants force some people to remember things they would rather forget

Conclusions

- Still in its infancy
- Very little animal or human models
- Designing software to mimic reasoning and deductive ability is no easy task.

Final Thoughts

- Materialists: world is objective matter
- Idealists: world is acquired from mind
- Kant: The Metaphysical